REMARKS

Claims 1-5, 7-10, 12-16, and 18-21 are all the claims pending in the application. Claims 6, 11, 17, and 22 are canceled, above. Claims 1-5, 7-10, 12-16, and 18-21 stand rejected on prior art grounds. Applicants respectfully traverse this rejection based on the following discussion.

I. The Prior Art Rejection

Claims 1-5, 7-10, 12-16, and 18-21 stand rejected under 35 U.S.C. §102(b) as being anticipated by Andricacos et al., herein after "Andricacos" (U.S. Patent No. 5,937,320). Applicants respectfully traverse this rejection because Andricacos does not teach or suggest the claimed "stabilizing copper layer on said barrier layer" as defined by independent claims 1 and 12 or the "copper and tin-based solder alloy bump" defined by independent claims 7 and 18 that comprise "an amount of copper sufficient to balance the chemical potential gradient of copper across said barrier layer" where the solder bump "comprises a lead-free solder."

The Office Action essentially admits that Andricacos does not directly teach the claimed stabilizing copper layer/alloy bump that have an amount of copper sufficient to balance the chemical potential gradient when the Office Action argues that there is no reason to believe that the copper layer of Andricacos would not have an amount of copper sufficient to balance the chemical potential gradient and where the Office Action alternatively attempts to ignore this limitation by arguing that it is merely functional. As shown below, the limitation is clearly "structural" in that it defines the amount of copper that is within the various structures, and Andricacos is silent regarding the amount of copper that should be used in any such stabilizing layer/bump.

First, Applicants note that the exclusive discussion of the cap layer (which the Office Action equates to the claimed "amount of copper sufficient to balance the chemical potential gradient") appears in the first paragraph of column 7 (lines 1-5) and also note that this paragraph is completely devoid of any explanation of how much copper should be utilized within the cap

layer (which is so unimportant to Andricacos that it is mentioned only once and is not even illustrated). There is no discussion in this paragraph (or any other portion of Andricacos) of the usefulness of balancing the chemical potential gradient to prevent copper diffusion from the barrier layer. Instead, this paragraph merely recites that a cap layer can be formed on the barrier layer 18, without further explanation. Therefore, it cannot be argued that Andricacos directly teaches the claimed structure because this paragraph does not contain any explanation that the cap layer should have "amount of copper sufficient to balance the chemical potential gradient" as claimed.

The Office Action argues that because Andricacos discloses a layer that can include copper over the barrier layer 18, there is no reason to believe that this layer would not include the claimed amount of copper. In response, Applicants note that there are many reasons to believe that this layer would not include the claimed amount of copper. One of the reasons is that Andricacos does not discuss the problems that the invention was designed to overcome when lead-free solders are used. Andricacos specifically utilizes lead-based solders where Andricacos recites that the solder bump is "composed of Sn, Pb, and alloys thereof" and is preferably a SnPb alloy (column 7, lines 6-10).

As explained in the specification (page 1, last paragraph) copper diffusion from underlying copper layers through the overlying barrier layers, when using lead-free solders, increases the likelihood of delamination. The solder bump BLM structures are susceptible to reliability failures in the ball-limiting metallurgy (BLM), when used to support lead-free solders. With lead-free solders, copper will diffuse through the barrier metallurgy and into the solder, leaving the underlying layer of copper voided and structurally weakened. This migration of the BLM copper is driven by the chemical potential gradient across the barrier layer. Therefore, Andricacos does not consider this problem and, therefore, would not have considered utilizing an "amount of copper sufficient to balance the chemical potential gradient" because Andricacos was utilizing lead-based solders and not the claimed lead-free solders.

Secondly, the first paragraph in column 7 of Andricacos equates gold and tin as being equal as useful as copper for the cap layer (where Andricacos states "a cap layer composed of Au,

Cu, Sn, or a similar lateral"), even though the ball limiting metallurgy layer 16 is a copper material, again underscoring the fact that this layer is not used to balance the chemical potential gradient of the underlying copper material 16 as in the claimed structure. Thus, once again, Applicants submit that Andricacos simply does not contain any disclosure that would teach the claimed amount of copper that is used in the inventive structure.

Adding credence to the fact that Andricacos does not disclose the claimed amount of copper is the statement in the Office Action which proposes that claimed limitation is not structural in nature. In other words, because Andricacos does not disclose the claimed feature, the Office Action attempts to simply ignore this feature by proposing that it is not structural in nature. This tends to indicate that the feature is not actually shown in the prior art, thereby rendering support to the previous arguments.

Applicants note that the claim language "amount of copper sufficient to balance the chemical potential gradient" can only be considered structural in nature and not functional. Instead of a function being described, the amount of copper utilized is being defined. This amount of copper will vary depending upon other aspects of the design, including thicknesses of layers in the structure, sizes of structures, processing temperatures, processing pressures, etc. Therefore, a specific molar concentration, weight percentage, density, weight measurements, etc. would unnecessarily narrow the claims, in that the claimed invention can be broadly utilized with any manufacturing parameters so long as the amount of copper within the stabilizing layer/ball balances the chemical potential gradient. While Applicants note that this may require some experimentation upon the part of the user, this clearly would not amount to undo or unnecessary experimentation and instead would simply require the designer to consider the various thicknesses, chemical concentrations, etc. when balancing the chemical potential gradient. Indeed, this may not require any "experimentation" at all, and instead can merely comprises a mathematical calculation to balance chemical potential gradient done during device design.

Applicants also note that there is no requirement in the MPEP that molar ratios, weight percentages, thicknesses, etc. be specific when the structure can be defined in terms of its performance characteristics. For example, a structure can be defined as being strong enough to

support another structure, the structure can be defined as having a melting point above or below another structure, and structures can be defined to have chemical concentrations similar to or balancing other structures. When considered in this light, the claimed language "amount of copper sufficient to balance the chemical potential gradient" is clearly structural in that this language defines the amount of copper that is utilized, as opposed to some performance goal that is achieved. The amount of copper used will vary depending upon the chemical potential gradient that is across the barrier layer within each given design. Therefore, the amount of copper can vary from designed to design and a requirement to define this amount of copper as a specific thickness, molar concentration, weight percentage, density, etc. unnecessarily narrows the claimed invention.

Therefore, Applicants submit that the language "amount of copper sufficient to balance the chemical potential gradient" within the claims defines the amount of copper that is within a given structure in a way that does not utilized units of measure and, therefore, more accurately captures the spirit and scope of the invention disclosed.

Thus, it is Applicants position that Andricacos does not directly teach (or suggest) the claimed "stabilizing copper layer on said barrier layer" as defined by independent claims 1 and 12 or the "copper and tin-based solder alloy bump" defined by independent claims 7 and 18 that comprise "an amount of copper sufficient to balance the chemical potential gradient of copper across said barrier layer" where the solder bump "comprises a lead-free solder" and that such features are structural. Therefore, it is Applicant's position that independent claims 1, 7, 12, and 18 are not anticipated by Andricacos and are patentable over the prior art of record. Further, dependent claims 2-5, 8-10, 13-16, and 19-21 are similarly patentable, not only by virtue of their dependency from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

II. Formal Matters and Conclusion

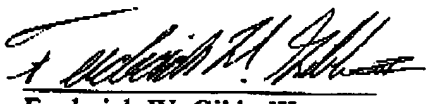
In view of the foregoing, Applicants submit that claims 1-5, 7-10, 12-16, and 18-21, all the claims presently pending in the application, are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary.

Please charge any deficiencies and credit any overpayments to Attorney's Deposit Account Number 09-0458.

Respectfully submitted,

Dated: 1-27-05



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